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TECHNIQUES FOR THE COLLECTION OF MICROCOLEOPTERA OF THE FAMILIES PSELAPHIDAE, PTILIIDAE, AND SCYDMAENIDAE

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The following account of collecting techniques employed on a series of field trips was initiated because the data accumulated might make future efforts more profitable by increasing efficiency. In general, the same basic technique are almost equally effective for the capture of representatives of the families Pselaphidae, Pitliidae, and Scydmaenidae; in fact, the normal pattern of occurence of these in essentially the same or equivalent habitats makes it almost impossible to collect one of them while missing the other two. Few, if any, of the methods in the following discussion are completely original, since my work has relied heavily upon discussions and suggestions of many people, chief of which have been Professor Orlando Park of Northwestern University, Rupert Wenzel and Henry Dybas of the Chicago Natural History Museum, and Harrison R. Steeves, Jr. of Birmingham, Alabama. To these go my thanks for making collection of these microcoleoptera possible and more profitable.

Previous work in this field by specialists has involved a number of techniques. Some of the more common of these would include hand-picking of various kinds of debris, especially under bark of trees, stones, or boards on suitable habitats; sifting material onto a white sheet through a screen; examination of the nests of ants and termites (Park, 1929, 1932, 1949, 1949, 1965); light trapping; and liberal use of the Berlese funnel and its modifications. Certainly all these methods have produced in the past; in fact, they are historically responsible for most of the material already collected and described. Moreover, although these families are not uncommon, their representatives are small enough and localized enough that accidental captures are relatively infrequent. Even in the past, most of the material on which classical research was done has been collected by a few workers who amassed impressive samples of material, usually from restricted areas. The names of Schmitt, Casey, Brendel, Ulke, LeConte, Fender, and many others are perpetuated in species names in these families for just this reason.

Three basic techniques seem to be important in the collection of these miniatures of the insect world, namely: selection of suitable material

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usually from particular habitats; concentration or examination of large quantities of this material; and use of as many methods of automatic extraction as possible.

Unfortunately, the first of these prerequisites has proven to be the most difficult to fulfill, since recognition of proper or at least promising habitats usually comes only through the slow acquisition of experience, often after an exorbitant expenditure of at least time if not also money. A few generalizations apply often enough, nevertheless, to aid the novice as well as the more experienced collector. The three families are all basically forest groups, probably arising in the not too distant geological past as members of floor communities and radiating from these to their present distribution (Park, 1947, 1965). This coupled with the fact that they have a relatively low vagility and are almost exclusively nocturnal leads the collector through an oft-times futile search for the most stable, dark, humid habitats that could be construed as forest-like. The five types of communities which have been most productive are bogs, forests, prairies, caves, and debris piles, and in almost all cases the stratum inhabited is the floor or its extensions.

A bog can be defined as an area with little or no drainage, a situation which often leads to extensive development of mosses as floor cover. These mosses, notably Sphagnales in the northern United States, are the most important habitat for microcoleoptera in these situations. The general pattern of collecting usually employed has been a systematic sifting of material with manual collection from the debris until an aggregation is found which warrants the use of the Berlese funnel. The groups appear to migrate, especially seasonally, so that a variety of situations may have to be tested to find a suitable aggregation, but once this is accomplished the Berlese funnel can usually be used to advantage. In any case, a few species are too minute for manual collection and must be collected automatically. In general, hummocks of mosses will yield proportionally more material than the areas between them, except during very dry periods; and the smaller animals, notably *Bibloplectus* among the Pselaphidae, may be found most commonly in the masses of fern rhizomes laid down by the genus *Osmunda*. Occasionally the animals tend to extreme aggregation, so that poor yields in moss-covered areas may be supplemented by worth-while yields from isolated or peripheral hummocks. In these situations completely isolated clumps of moss around shrub bases or litter accumulations in bush forks often yield exceptionally well, especially in flooded situations.

Work in forests cannot be limited to such a small number of habitats, probably because the families in question evolved in forest situations and have adaptively radiated to a greater degree in the greater length of time available. But a few situations yield well enough to mention in the interests of efficiency: tree holes and forks (Park, Auerbach, and Corley, 1950; Park and Auerbach, 1954), log mold (especially that protected by bark), ant nests, tree buttress debris or its equivalent, and moist pockets on the floor, especially those next to rotting logs on slopes. Also the size of the population and the number of species present often depends on the successional stage of the major community; for example, in the Chicago area the best yields of species and individuals come from pre-climax oak or climax beech-sugar maple forests. The collector should be aware of habitat specificity even within the general forest community. In tree holes and forks, large cavities close to the ground generally have larger populations, and those with a cover of leaves or wood chips are better than unprotected ones. Tree forks generally do not support a large population except for basal forks in pine forests in the Gulf states, possibly because of the paucity of tree holes, but axillary debris from palmetto yields exceptionally well in the south. Finally, collection of debris from the floor should take into account depth, protection, moisture supply, and any other factors which would give the greatest stability to the habitat. Some of the most interesting collections have been obtained from litter interlaced with fungal hyphae under conifers or in pseudoforks (accumulations between intertwined buttresses of adjacent trees) in southern forests, and from mixtures of debris under rhododendron in the southern Appalachians. Generally destructive flooding or burning eliminates the possibility of good yields, but "islands" in swamp situations often yield exceptionally well.

Prairie species are probably the least well known for a variety of reasons, some of which may be the apparent dissimilarity between prairie and forest, the need for different collecting techniques, and the rapid disappearance of natural prairie through the efforts of man. There are, nevertheless, a number of species which are restricted to this community and which are only slightly more difficult to find than the prairies themselves. In the midwestern United States prairie relicts can often be found by spotting a trio of biotic indicators, namely: compass plant, rosin weed, and rattlesnake master. Good yields have been obtained from three collecting methods. First the "trapping" of beetles is done by supplying a cover of isolated boards to the floor. Examination of these boards, especially after a spring fire, often gives good yields, but aestivation of the populations may lead to their apparent absence during the summer. Ant nests also yield some species and Berlese extraction from floor clumps, piles of grasses, or debris often gives good results (Park, Auerbach, and Wilson, 1949, 1953).

Caves offer a rather restricted group of Pselaphidae which are especially important in a study of speciation (Park, 1951), but the other two families are either uncommon or absent. In these interesting situations the majority of animals will be found under rocks near the entrance, but at least one genus has retreated out of this twilight zone to the darkness of the interior. Small limestone caves with small openings, dampness but no stream seem to yield best. In the United States, the vast majority of records have come from older caves in the southern Appalachians and its extensions into Alabama and Tennessee.

The search for microcoleoptera has so far been channeled to natural, stable communities, but one group of unnatural habitats yield some species in good number. The yield in these situations is enhanced by a surrounding natural area, but these microseres attain enough stability of their own with time to support flourishing populations. These are basically piles of debris, and yield increases with size and age, although aggregations of some species in larger piles may make finding them more difficult, and extreme age leads to the disappearance of the pile. Three major types are important, namely: accumulations of grasses, sawdust piles, and piles of horse manure (Wagner, 1962). The last of these might at first glance seem the least likely to produce because of the origins and habits of the families, but a few species have successfully adapted to this habitat and in many cases attained a nearly world-wide distribution, possibly because of a lack of serious competition. Grass accumulations take the form of compost heaps, hay stacks, and grass cuttings on the periphery of natural communities, especially swamps. So long as moisture is retained and temperature extremes are avoided yields may be surprising. Finally, sawdust piles often prove to be a mecca to the microcoleopterologist, with the majority of species therein apparently adapted to life in buttresses or subcortical log mold of forests. The Berlese funnel should always be used if the sawdust is over ten years old because of the small size of many of the species. Piles of leaves or bark chips on the sawdust may be especially rich, but interesting yields of larger forms come from under slabs of wood laying on the sawdust or buried in it. Concentrations of Coleoptera seem to occur near the periphery of the piles, which may be a consequence of heat accumulation nearer the center or a reflection of aggregation and thinness of the pile near its edge, but which is enhanced by encroachment of natural vegetation (and protection). These three types have yielded well in the past, but there are many similar situations which yield on occasion, so that it might pay to watch for suitably aged and protected debris piles in general.

One distressing fact of the distribution of these microcoleoptera has been recently discussed by Dybas (1966). The small size of the animals reduces their fecundity directly by limiting the number of eggs carried by the female. This affects collecting because the animals cannot breed fast enough to "fill" an extensive forest, leading to the anomalous situation of small stands yielding better than extensive ones. And situations of restricted size may arrise naturally in "tension areas" such as the Chicago area where forest, bog, and prairie interdigitate, or Highlands County, Florida, where the one hundred foot plateau drops off into cypress and magnolia swamps, giving maximum variability and with it maximum collecting efficiency.

With the exception of the Ptiliidae, most microcoleoptera are not common, although few are truly rare. The collector who does not need exact quantitative data, therefore, should attempt to concentrate his samples to obtain both large numbers of species and, more important, large series of most of the species. For work with light traps this involves simply the enclosure of the apparatus in a screen with openings of one-half inch or smaller so larger flying insects, notably Lepidoptera, do not clutter the collections. In this case the importance of the concentration lies with the sorting, which becomes infinitely easier. Dybas has also used a very fine mesh net to advantage for collecting which might be considered a method of light trapping. This is mounted on a regulation hoop and handle from an insect net and held out the side of a slowly moving car while driving at dusk in forested areas with the lights on bright. Yields from this system depend on the same physical conditions as does light trapping, with highest yields on warm, humid nights. Floatation of organic material in water with subsequent drying and Berlesing has also been suggested, but I have done little of this. My most effective method was shaking down litter with a riddle or other mounted screen followed by Berlese extraction. This increases the floor area sampled by eliminating material which had not aged enough to provide habitats for microcoleoptera and breaks up some materials from which they could not otherwise be dislodged. This system has only limited applicability when dealing with prairie sod, tree hole mold, manure, and sawdust, but it becomes especially important in concentrating leaf litter, subcortical log mold, and straw piles, and the riddle alone is grossly effective when used on mosses in swamps and bogs.

Generally, methods other than automatic can only be justified as a means of testing habitats for possible subsequent treatment with Berlese funnels. One type of this apparatus is diagrammed in Peterson (1964, 164: 1, 2, and 3), but my funnel utilizes a single slope, detachable brackets, quarter-inch mesh screens supplemented with cheesecloth, and simple wire harnesses developed by Mr. Steeves for bottle attachment. For maximum (but non-quantitative) yields 100 watt bulbs are used and the funnels allowed to run for only six to ten hours, depending upon the water content of the sample, since tests indicated that microcoleoptera react immediately to heat even though the majority of soil arthropods are vagile or resistant enough to be dislodged only by the slower drying of the samples. Using this timing, which allows for three batches of litter a day, and running banks of ten to twenty funnels hundreds of localities and thousands of habitats can be run through in a year's time.

In any case, expect to be surprised both favorably and unfavorably in your collecting efforts directed to microcoleoptera. The methods outlined herein have been used to collect as many as a thousand or more a day under favorable conditions, and as few as two or three a day in unfavorable ones, but the lesson to be learned from the efforts expended is some idea of the basic ecology of these animals. The more information you derive from your successes and failures about the habitats and habits of these animals, the easier it will be to find them in the future.

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LITERATURE NOTICE

STUDIES ON THE BEETLES LEPTINILLUS VALIDUS (HORN) AND PLATYPSYLLUS CASTORS RITSEMA (COLEOPTERA: LEPINIDAE) FROM BEAVER. By D. M. Wood. Proc. Ent. Soc. Ontario 1964 [1965] 95:33-63, 35 figs. 1965.—The egg, larva, and pupa of both species and the adult of the first species are described and illustrated. Life histories, including host relationships, activities, food getting, temperature requirements, laboratory rearing, mating, and egg laying, are described and discussed. These ectoparasitic beetles are fascinating, and so is this study.